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Addressing the factors responsible for the misunderstanding of Technology Education with other subject fields

Abstract

Technology Education was introduced and rolled out in South African schools in 1998. It has been twenty years since its implementation, yet it is being confused with other traditional subjects. Therefore, even though it is expected that Technology Education should be known for what it is exactly, it is still misunderstood, misconceived and misrepresented. There are factors that contribute towards its misunderstanding (a failure to understand it), misconception (incorrect opinion caused falsely thinking about or understanding it) and misrepresentation (giving a false or misleading account of its nature), such as it being confused with Engineering Education, Educational Technology, Science Education and Technical Vocational Education and Training. Misunderstanding Technology Education causes its misconception and misrepresentation; hence, in this article I use misunderstanding to cover misconception and misrepresentation as well. There is no dedicated literature (at least in South Africa), dealing with this problem in detail; only piecemeal definitions contained in studies about Technology Education exist. Hence, this article explores factors leading to the misunderstanding of Technology Education. As part of addressing this problem, the article builds on the Meaningful Learning in Technology Education Framework to accommodate a more expanded understanding of Technology Education that may help to defuse its misunderstanding. The article contributes knowledge in the scholarship of the understanding Technology Education – if Technology Education scholars, teachers and the broader readership do not have a clear understanding of Technology Education, how can those who are being taught the subject, i.e. the learners, be expected to understand it?

Keywords: *Technology education, indigenous technology, mis-understandings, factors, meaningful learning in technology education framework*

1. Introduction

Technology Education was introduced as part of Curriculum 2005, which was rolled out in 1998. It is still one of the subjects in the Curriculum and Assessment Policy Statement (CAPS). However, twenty years after its introduction, Technology Education is still misunderstood, both outside and inside the subject (Daugherty & Wickein, 1993). Mapotse (2012) states that the term technology is overused with little understanding. Misrepresentations and stereotypical perceptions about Technology Education flood literature (Daugherty & Wicklein, 1993; Dugger & Naik, 2001; Indiana Technology Education Curriculum Standards, 2006; Dugger, 2008; El-Deghaidy & Mansour, 2015) from international down to local. In the United States context, technology is "widely misunderstood, misdefined and distrusted" (Indiana Technology Education Curriculum Standards, 2006, 3). Furthermore, Maley and Wenig (in Daugherty & Wicklein, 1993) identify a considerable confusion that still exists about what characteristics exemplify Technology Education. Almutairi (2009) conducted a study that explored New Zealand Technology teachers' perceptions of Technology and Technology Education through interviews. His findings revealed obstacles attributed to the poor perception of teachers regarding Technology and Technology Education, e.g. insufficient funds, lack of mentoring for new teachers by senior teachers and lack of regular meetings for Technology teachers. Regionally, a few studies confirm the confusion that exists about Technology and Technology Education. For instance, in addition to confusing Technology Education with other traditional subjects in Malawi and Botswana, Moalosi (1999), Obikeze (2011), Ogunbure (2011), Gaotlhobogwe (2012), Chikasanda, Mtemang'ombe, Nyirenda and Kapengule (2014) and Ruele (2017) are of the view that Technology Education is devoid of the local meaning, thus adding to the misunderstanding of Technology Education. Gaotlhobogwe and Ruele in particular blame the Botswana Technology Education curriculum for adopting the Cambridge curriculum.

Though Technology Education curricula aim to achieve the technological literacy of those taught and the citizenry ultimately (Daugherty & Wicklein, 1993), the misunderstanding of Technology Education still exists. This is also the situation in the South African context as stated above. While these studies look into the literacy problem and raise issues with the misunderstanding that surrounds Technology Education, scholars have not yet turned their attention to the factors that cause this misunderstanding, hence the need for the current study. This article explores these factors and thus addresses the research question: "What are the factors contributing to the misunderstanding of TE?" It is important to address these factors because the misunderstanding in question frustrates the implementation (Daugherty & Wicklein, 2000) and content (Williams, 1996) of Technology Education. Addressing this question will also assist in clarifying the specialisation of Technology Education teachers and scholars, as they are often mistaken for Educational Technology specialists, or even Science Education specialists.

The course that this article takes is to define Technology and Technology Education, discuss the Meaningful Learning in Technology Education Framework undergirding the study, and reflect on its claims, which have subsequently led to the discussion of the factors that contribute to the misunderstanding of Technology Education. The article concludes with the adapted Meaning Learning in Technology Education Framework.

2. Technology and technology education

It is important to first clarify the concepts Technology and Technology Education from the body of literature as these concepts suffer their misunderstanding and thus have attracted the factors that create this misunderstanding. Terms that may create misunderstanding because of their usage need to be explained (Pudi, 2006). The definition of these concepts rests mainly on *design* in the context of solving technological problems and meeting human needs and/or wants. Dugger and Naik (2001:31) define technology as design, making, problem solving, technological systems, resources and materials, criteria and constraints, processes, controls, optimisation and trade-offs, and invention, as well as other topics that relate to human innovation. Design encapsulates theory (content knowledge) and practice (procedural knowledge), as these relate to learning a range of material processes for metal, wood, plastic materials, textile, leather and food materials (Kumar, 2002:125). Technology can be studied in order to learn about the technological processes and knowledge needed to solve problems and to extend human capabilities (International Technology and Engineering Association, 2000:242). In CAPS, technology is defined as "the use of knowledge, skills, values and resources to meet people's needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration" (Department of Basic Education, 2011:8). It makes learners technologically literate by giving them learning opportunities to:

- develop and apply specific design skills to solve technological problems;
- understand and use the technological concepts and knowledge responsibly and purposefully;
- appreciate the interaction between people's values and attitudes, technology, society and the environment

(Department of Basic Education, 2011:8).

These definitions show that Technology Education provides learners with opportunities to acquire technological knowledge and skills as they engage in problem-solving processes. In the learning process, learners use different materials and apply techniques to manipulate the environment carefully. On completion, these learners can participate as professionals in fisheries, agriculture, mining and so forth.

Technology Education was introduced in the United States in the 1980s as a replacement for industrial arts education (Litowitz & Warner, 2008, 251). Thereafter, it was included in the curriculum in countries such as England, France, Finland, Canada, and ultimately, in South Africa (Jones, Buntting & De Vries, 2011, 5). Technology Education has different names in the afore-mentioned countries. For example, in England Technology Education is known as Design and Technology, and in Ireland as Technology and Design. In South Africa, it is called Technology, and at times, Technology Education. Other African countries such as Botswana and Zimbabwe endorse Design and Technology, which they adopted from the British curriculum.

There are several approaches to Technology Education, which are summarised according to Black (1996) as follows:

- *Craft approach:* applies knowledge and skills in the transformation of materials into fabricated objects, cultural and personal value, and traditional design. Learners make things based on prescribed designs. Classrooms are equipped with machines and tools for woodworking, metal working, electrical, etc., with an emphasis on psychomotor skills rather than design.
- *Occupational/vocational approach:* focuses on hands-on activities and transforming materials into products and industrial practice skills. Classrooms are equipped with machinery from industry.
- *High-tech approach:* focuses on modern industry with a desire to shape the skills base of a future workforce. Classrooms are equipped with the latest high-powered machinery.

- *Applied science approach:* relies on science to explore new applications of technology and study of two in close association with each other.
- *Technology concepts approach:* focuses on learning processes, which result in technological developments, and emphasises the theoretical understanding.
- *Design approach:* emphasises practical capability, active learner involvement in problem-solving and design–make–evaluate activities.
- *Science–technology–society approach:* curricula are organised around societal issues and connections between classrooms and [the] outside world.
- *Integrated subject approach:* integrates a number of subjects into a framework, which provides an understanding of Technology Education.

Generally, countries have adopted the design approach. Specifically, in CAPS (Department of Basic Education, 2011), emphasis is on the design process as the backbone of Technology Education, which involves investigation, design, making, evaluation and communication. This approach includes elements of the other approaches explained above. For example, at the Intermediate Phase, Technology Education is combined with Natural Sciences, and is called Natural Sciences and Technology. The core content areas of Technology Education include Design Process Skills, Structures, Processing of Materials, Mechanical Systems and Control, Electrical Systems and Control, and Technology, Society and Environment. Technology, Society and Environment includes the impact of technology, the bias of technology, and indigenous technology. Specifically, the CAPS state the following:

> *Wherever possible, learners should be made aware of different coexisting knowledge systems. They should learn how indigenous cultures have used specific materials and processes to satisfy needs, and become aware of indigenous intellectual property rights (Department of Basic Education, 2011:10).*

3. Theoretical framework

This study uses the Meaningful Learning in Technology Education Framework of Kelly and Kellam (2009), as illustrated in figure 1. The choice of this framework is informed by its emphasis of pragmatism in relation to the application of *design.* Therefore, this theoretical framework adds to addressing the factors responsible for the misunderstanding of Technology Education. In attempts to understand Technology Education, it is important to place the learner at the centre, as what is learnt about technology, impacts hugely on the learner’s understanding of what technology is all about. It is in this light that Technology Education can be understood through a framework that is in line with, according to Kelly and Kellam (2009), the needs of today’s learners and the new knowledge of teaching and learning. Kelly’s and Kellam’s (2009) framework consists of five main concepts, which are pragmatism, constructivism, context, engineering design and systems thinking, and problem-based teaching (see figure 1).

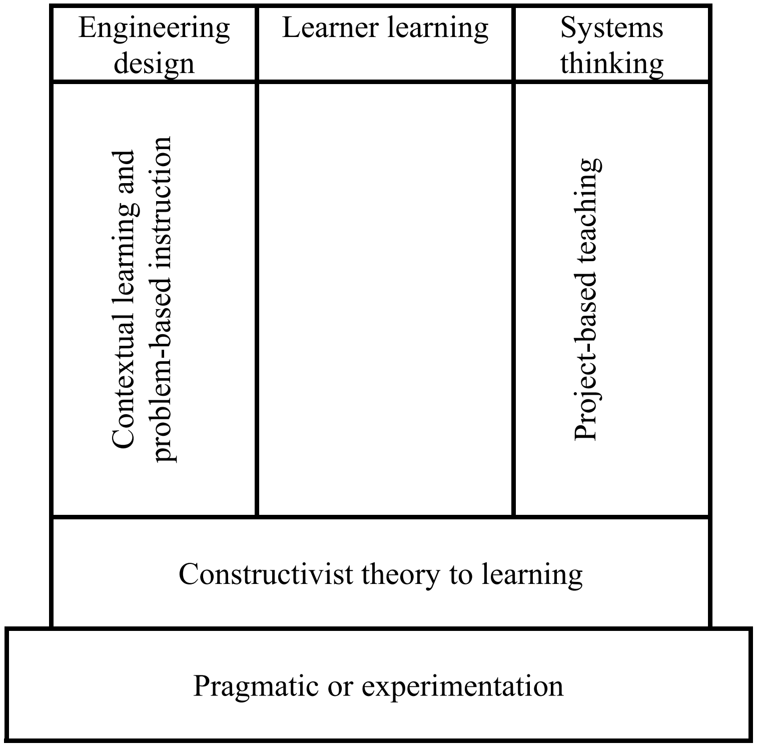

Figure 1: Meaningful Learning in Technology Education Framework (adapted from Kelly & Kellam, 2009)

These authors claim that the constructivist approach to learning, as informed by pragmatist philosophy, is the foundation that holds all other learning theories and approaches to learning, namely, contextual/problem-based and project-based learning, and engineering design and systems thinking. Learner learning is a keystone of the framework, which implies that learners should identify and solve open-ended problems faced by today's society. From a pragmatic point of view, these authors claim that Technology Education should equip learners with knowledge, skills and abilities, so that they can live, work and function in the current technological society. However, they may not be able to if they have a narrow understanding of technology. That is why freeing Technology and Technology Education from the cloud of their misunderstanding is important for learning Technology and building the academic identity of the teachers.

The pragmatist philosophy is premised on the fact that one can gain knowledge through problem solving, and it places great emphasis on critical thinking and open-minded reasoning, in pursuance of solutions to the world's problems. This claim corroborates Barron and Darling-Harmond (2008), who claim that design and problem-solving learning activities sourced from authentic contexts, provide relevant education to learners, who will be motivated to learn and respond well to the demands of today's fast changing world. In this manner, learners can be prepared to cope in today's rapidly changing world, which is subjected to ubiquitous and innovative technologies, by applying their acquired creative abilities.

The claims associated with constructivism are that a learner cannot be treated as a passive receiver/acquirer of knowledge and skills, but that he/she should be actively involved in cooperative learning to construct new understandings. Constructivism enhances learners' understanding of complex systems and heightens their interest, engagement and motivation in the learning activities. Constructivism is most appropriate in the learning of Technology, as Technology Education makes learners identify authentic problems in relevant contexts. Added to these authors' claims, Crawford (2001) perceives constructivist teaching as an enabler for learners to relate their learning in the context of their lives or pre-existing knowledge; experience learning by doing or exploring, discover and invent; apply the learned concepts; cooperate by sharing, responding and communicating with others; and transfer knowledge in new contexts. This suggests the importance of context in learning, namely, it facilitates the understanding of technology. Context places learning in a specific physical context and social environment so that learners can acquire knowledge, which is intimately associated with such a setting. However, contextualisation of learning does not close out the need for transference of knowledge through exposing learning to multiple experiences to prepare learners to operate within global technological and societal contexts as well. This is important for treating conceptual and procedural knowledge in Technology Education. In a technological sense, context and problem solving converge as learners become puzzled by what could be happening in authentic contexts and try to figure out solutions to those problems in a self-directed and collaborative manner.

Kelly and Kellam cite Wicklein and Daugherty, who argue that engineering design is the ideal platform for addressing standards for technological literacy, and creates the teaching model that attracts and motivates learners from all academic levels. Thus, from an engineering perspective, learners need the required job skills such as communication, analytical, problem-solving, creative and critical thinking skills, which can position them to perform and fit well into the job market.

Systems thinking is about synthesising all the relevant information about an object for us to have a sense of it as a whole (Kay & Foster cited in Kelly & Kellam, 2009, 44). This may call for reducing the system down to its constituent parts and studying their relationships. In Technology Education, this can happen practically by disassembling a cell phone in order to study its parts and their functional relationships.

4. Reflections on the meaningful learning in technology education framework

Technology Education cannot be taught theoretically and away from the authentic context, hence the pragmatic sense provided by this framework. Learners have to think creatively and critically, and execute the assigned design projects. From the pragmatic and constructivist points of view, the Meaningful Learning in Technology Education helps teach learners through this approach. This framework also helps to set tasks for the learners that are relevant to, and which represent, authentic contexts that learners are familiar with. This primarily suggests contexts that learners come from, in order for them to relate their design projects to the problems that surface in the said contexts.

In the South African context, where indigenous knowledge systems are valued and thus, appears in the CAPS, it becomes paramount that attempts to clear the misunderstanding of Technology Education should include indigenous perspectives. In addition, interest must be inculcated in the learners so they can relate their learning to the projects they create, e.g. the creative industries in textile, bridge design and construction, house design and construction and so forth. Nonetheless, the indigenous knowledge systems perspective is mis- or under-represented as it can be seen in the consulted literature about the definitions of Technology and Technology Education above. This point is deliberated upon later under the factors. I argue that perceiving Technology Education from the western industrial perspective only is limiting and contributes towards its misunderstanding especially in the developing or indigenous contexts where technology could have a contextual meaning that is informed by local forms of technology. Hence, other forms of knowledge such as indigenous knowledge, that help build a contextual understanding of Technology Education, should be integrated into the definition and knowledge construction. These knowledge forms and their bearers have suffered coloniality and have been accused of being devoid of any possible contribution. Dewey (1930:3) cautions in this regard:

> *We are given to associating creative minds with persons regarded as rare and unique, like geniuses. But every individual is in his own way unique. Each one experiences life from a different angle than anybody else, and consequently has something distinctive to give others if he can turn his experiences into ideas and pass them on to others.*

Furthermore, Kelly and Kellam seem to overemphasise engineering in the Meaningful Learning in Technology Education Framework. However, they do acknowledge the limitation of confining Technology Education to the engineering concept. The framework should have accommodated this limitation by factoring in Technology Education next to the design block. An attempt to define Technology Education through the Engineering subject and other subjects such as Science Education, Educational Technology and Technical and Vocational Education and Training, which seem to portray indifference between Technology Education and these other subjects, is undesired and adds to the factors that cause the misunderstanding. This and other factors receive attention in the next section. Lastly, Technology Education should be understood from the point of view of the ecosystem of knowledge that helps build and improve it. Systems thinking is useful in this regard. However, again, Kelly and Kellam emphasise systems thinking in as far as its constituent parts. The scope of systems thinking should transcend the phenomenon’s boundaries to other phenomena that build onto it. From a subject point of view, this is where Technology Education needs to be related to other subjects, especially those that lie close to it, but showing its points of convergence and divergence with those subjects. The integrationist curriculum approach that is promoted in the CAPS should promote this consideration.

5. Factors responsible for the misunderstanding of technology education

5.1 Misleading internet search results

Searching for literature about Technology Education on the internet using keywords such as “Technology”, “Technology Education” and “Definition of Technology” yields results about Educational Technology. It is only when one searches literature through online Technology Education journals or authors and titles of publications that one gets the expected results. The fact that searches of Technology Education literature yield results about Educational Technology adds to the misunderstanding of Technology Education and can be misleading to Educational Technology educators and scholars, who may confuse it with Educational Technology.

5.2 Technology Education taught by unqualified teachers

Adding to the misunderstanding of Technology Education is the fact that when it was first rolled out in 1998 as part of Curriculum 2005, there were no trained Technology teachers (Mapotse & Gumbo, 2013). Consequently, teachers qualified in other traditional subjects were asked to volunteer to teach Technology. Technology Education's newness in the curriculum compared to other subjects explains this state of affairs. McCormick (1997) writes that Technology Education has little or no established history, and this has contributed to the misunderstanding of Technology Education. Thus, many Technology Education teachers are under-qualified to teach the subject, and feel incompetent to do so (Mapotse, 2012). This claim concurs with Garson (2000), who states that because of the relative newness of Technology Education, teachers in the field are still grappling with what it is actually. Attempts to scrap Technology Education from the curriculum during the curriculum reviews of 2000 and 2009, have not only added to the confusion, but dampened Technology Education teachers' and other stakeholders' keenness to know more about the subject.

5.3 Educational technology researchers who are "ill-informed" about technology education

According to Laufenberg (2009), many people equate technology to computers or other technological and electronic products in an educational setting. Researchers who are not Technology Education educators/scholars or whose research field is in Educational Technology have contributed to the misunderstanding of Technology Education. A case in point is an article that I read during the writing of this paper about the implementation of Technology Education in South Africa. The title and sectional headings of the article are about Technology Education, however, the text is about technology integration in teaching, and not Technology Education. The first sentence in the introduction relates to information and communication technology. In that sentence the authors talk about the use of technology in education as becoming an increasingly important part of higher and professional education, while the last sentence in that section deals with Technology Education. The authors make a claim that literature on technology is flooded by misrepresentations and stereotypical perceptions of technology and Technology Education. While these authors attempted to address the problem of the misrepresentation of Technology Education, they complicated it further, unfortunately. They confused it with Educational Technology.

In the authors' quest to overcome the misrepresentations and stereotypical perceptions of Technology Education, they exacerbated them. One section is titled as referring to Technology Education. However, the text in that section is misleading, as it cites a survey that was administered on the primary school learners to gather their perceptions about children's engagement with information and communication technology, both within and outside of the school context. In addition, the investigation targeted a language subject instead of Natural Science and Technology. This confirms that the authors focused on Educational Technology. The items in their survey instrument seem to relate to Technology Education, but the accompanying discussion of the findings is about information and communication technology. Of the 48 sources quoted in the article, only 9 are on Technology Education, and these have been misinterpreted and misapplied in the article.

5.4 Varied interpretations of technology

The misunderstanding of Technology Education also stems from varied interpretations of technology. Dugger (2008:1–2) reports on two interview-based surveys conducted in 2001 and 2004, among Americans 18 years of age and older, concerning their understanding of what technology is. Participant responses were as follows:

- Science and technology are basically one and the same thing (59% in 2001 and 62% in 2004);
- Narrow view of technology as being computers, electronic devices and the internet (67% in 2001 and 68% in 2004);
- It is very or somewhat important for high school students to understand the relationship between science and technology (98% in 2001); and
- Schools should include the study of technology in their curriculum (97% in 2001 and 98% in 2004).

The views of the participants in the above findings show that Technology Education is confused with computers or Educational Technology and science. This ties in well with 5.1 and 5.3 above.

5.5 Under-representation of indigenous knowledge systems in the CAPS

The definition of technology in the CAPS misses out on indigenous knowledge systems. Given the historical marginalisation of indigenous knowledge systems and sustainable development, indigenous knowledge systems cannot be left to chance by not giving it serious attention. The CAPS touches on indigenous technology rather superficially (refer to section 2 above). This is the case in the following instances:

- “Where possible” increases the vulnerability of indigenous technology to exclusion. The phrase lacks commitment to indigenous knowledge systems.
- “Made aware” and “become aware” do not mean teaching about indigenous technology, but merely make learners aware of it.
- “Have used” risks indigenous technology to be limited to the past. This adds to the prevailing misunderstanding of indigenous knowledge systems.

The statement should rather have been formulated as: *Learners should learn about different coexisting knowledge systems and how indigenous cultures use specific materials and processes to satisfy needs, as well as consider indigenous intellectual property rights.*

Indigenous technology is referred to as local or traditional knowledge, folk knowledge, people’s knowledge, traditional wisdom or traditional science (Senanayake, 2006). It is expressed through indigenous knowledge, methods and processes of agriculture, food preparation and conservation, health care and education (Senanayake, 2006). There are tangible and intangible forms of technology, with culture lying at the heart of all of them (Custer, 1995; Ogunbure, 2011). It can thus be argued that, “not every problem-solving activity will or should require a physical prototype or artefact” (Kelly & Kellam, 2009:45). According to Obikeze (2011), tangible and intangible forms can be categorised as physical (material) technology, e.g. bows and arrows, ploughs, and machines; social technology, e.g. methodologies, techniques, and organisational and management skills; communication technology, e.g. language, signs and symbols. These forms include cultural products, which can be classified as goods or services, and thus divided into material goods, e.g. soap, food, houses, and ornaments; social goods/services, e.g. values, norms, and customs; intellectual goods, e.g. ideas, abstract concepts, names, and terminologies.

In the light of the above, Obikeze (2011) pens down that technology is any human-made or culture-generated devices, formulations or organisations that may be used for the purpose of producing or creating needed goods and services. To express this in another way: technology refers to the knowledge, technical skills and resources available in a particular community and the environment, which the community occupies, and is used to meet its needs in order to ensure its sustainable development. The definition of technology given in 2 above, then, should consider this indigenous perspective.

5.6 Technology Education confused with other subject fields

5.6.1 Technology Education and Engineering Education

The National Center for Engineering and Technology Education proposes that Technology Education should follow design as conceptualised in engineering (Asunda & Hill, 2007, 3). The fact that the procedural terminology used in Technology Education and Engineering Education is the same, e.g. formulate a problem, generate alternatives, analyse and evaluate (Eggert cited in Williams, 2011, 398), does not mean that Technology Education and Engineering Education are the same (Kelly & Kellam, 2008). Engineering Education intensely depends on the body of knowledge from Science and Mathematics (Williams, 2011); if Engineering-based design is adopted 100 percent in Technology Education, it means that learners should be taught a considerable amount of Science and Mathematics. Science and Mathematics are used only partially in Technology Education when needed, and this affords all learners the opportunity to learn Technology. Engineering design makes use of mathematical analysis whereas Technology Education makes more use of conceptual design (Williams, 2011:399).

5.6.2 Technology Education and Educational Technology

The use of the name ‘Technology’ instead of Technology Education impresses upon the reader that Technology Education is synonymous with computer technology or information and communication technology (Volk & Dugger, 2005). I vouch for the use of Technology Education. Technology Education is a school subject intended to promote technological literacy in learners and to qualify them as engineers, artisans, technicians, and so on. Educational Technology, however, is the study of the facilitation of learning with the aim of making learning meaningful to learners by creating, using and managing appropriate technological processes and resources (Dugger & Naik, 2001). Thus, Educational Technology is about technology *in* education (Dugger & Naik, 2001:32), and is not Technology Education in the slightest. Teachers of all subjects, including Technology Education, should incorporate technology in their teaching (Al-Ammary, 2012).

Another way to distinguish between Technology Education and Educational Technology is by key words or phrases. The National Educational Technology Standards for Students related to Educational Technology include key words such as use of technology, media, multimedia, hardware and software (Dugger & Naik, 2001:32). Technology Education, on the other hand, uses key words such as design, creativity and critical thinking, solutions and investigation. However, both the literature on Technology Education and that on Educational Technology use the term *technological literacy*, which actually adds to the misunderstanding of Technology Education. Some of the key words listed above are also used in both Technology Education and Educational Technology, but signify different things for different intentions. For instance, design in Educational Technology may denote the design of a lesson, which incorporates technology, whereas it can signify a much more sophisticated way of designing solutions to technological problems in Technology Education.

Petrina (2003:64) refutes the notion of Technology Education and Educational Technology being synonymous, basing his argument on their evolution from the 1920th Industrial Education and Audiovisual Education (Petrina, 2003:65). Industrial Education aimed to provide working class children with knowledge, skills and values that would enable them to survive the effects of industrialisation. Audio-visual Education, on the other hand, was a teacher education subject aimed to equip women with the necessary knowledge, skills and values to integrate mass communication technology, namely cinema and radio, into their teaching. According to Petrina, International Technology and Engineering Education Association is in the process of promoting standards for technological literacy, similar to International Society for Technology Education, which promotes standards for technology literacy. He suggests that both International Technology Education and Engineering Education Association and International Society for Technology Education are caught up in theoretical differences, when the masses' observation of indifference is informed by practice.

However, Petrina switches to synonymising Technology Education with Educational Technology by acknowledging the conflation by the National Teachers Association and American Federation of Teachers of Technology Education with Educational Technology. The main thrust of the Technology Education-equals-Educational Technology argument is that the practices of both are information communication based, and so "when it comes down to IT, TE and ET, teachers are technology teachers" (Petrina, 2003, 70), wherein IT stands for Information Technology, TE for Technology Education and ET for Educational Technology. This is unfortunate, as naming Educational Technology teachers Technology Education teachers, has the potential to add to the confusion about what Technology Education is. Educational Technology teachers teach about the integration of technology in teaching, whereas Technology Education teachers teach Technology. The fact that Petrina (2003, 70) concedes, "granted, ET may be a subset of TE" is sufficient to acknowledge differences between Technology Education and Educational Technology – Educational Technology is but one of the specialised fields of Technology Education career-wise, but it is not Technology Education. I vouch for the distinction between these two.

Having said this, I also acknowledge converging lines of Technology Education and Educational Technology, namely, Technology Education, like any other subject, needs Educational Technology for pedagogical purposes in order to enhance Technology Education's teaching and learning. Technology Education also contributes the technologies that can be integrated in teaching and learning. Much of what happens in the Technology Education workshop is taught through Educational Technology as an aid for teaching and learning as stated above; for instance, when cutting (cold metal drop saw, power hacksaw, and jigsaw), shaping (wood lathe, metal working lathe, and milling machine), joining (welding, drill press, and horizontal drill), finishing (finisher, and sanders), and for computer-aided drawing.

5.6.3 Technology Education and Science Education

Scholars tend to use the terms *technoscience* and *technology as science* loosely (Davies, 1997), suggesting that technology and science are synonymous. Although technology and science lie very close to, and complement, each other, they are not the same thing. They have grown so close that they are often thought of as the same thing. This misunderstanding adds to the thinking that Technology Education teachers and learners are simply doing Science Education. The differences between Technology Education and Science Education can further be understood by dichotomising technology and science. For example, technology designs new products that did not exist before and creates successful artefacts and systems to meet people's wants and needs. On the other hand, science explores existing phenomena to attain new knowledge and pursues understanding for its own sake; technology creates effective, efficient, within-acceptable tolerances solutions; whereas science pursues truth, accuracy and the ideal; technology is need-/want-driven; whereas science is curiosity-driven (Herschbach, 2001).

Davies (1997) illustrates the lines of divergence and convergence between technology and science as follows:

- Technology as applied science view: Technological capability grows out of scientific knowledge, and the historical nature of technology takes little or no account of science. Designers, on the other hand, are open-minded and borrow other knowledges from other sources in their pursuit of solutions, e.g. science has a tendency to depend heavily on technology for both ideas and apparatus.
- Demarcationist view: Science and technology are independent, with differing goals, methods and outcomes, but it is practically unimaginable that technologists and scientists should engage in different research and development projects.
- Materialist view: Historically, technology enjoys precedence over science, e.g. experience with tools, instruments and other artefacts, whereas it should also be noted that most modern technology is deliberately scientific, as it embraces continual formal study and empirical investigation.
- Interactionist view: Theory and practice do not always go together; many scientists claim higher status for their conceptual frameworks, while engineers and designers are more pragmatic, and dismiss the abstractness of science. On the other hand, technology and science engage in a two-way interaction because scientists and technologists learn from one another in mutually beneficial ways.
- Indistinguishable view: Scientists feel that this view threatens their field because it dilutes its purity, when modes of thinking between these two have fundamental differences. However, the role played by technology and science in modern times in research and development overcomes any strict distinction between the two.

5.6.3 Technology Education and Technical Vocational Education and Training

Technology Education started as vocational training and the influence of industry on it has been, and is still, too strong (Sanders, 2003). Vocational Education entails a planned series of learning experiences, whose specific objective is to prepare individuals for gainful employment as semi-skilled workers or sub-professionals in recognised occupations, and in new and emerging occupations. Over time, Vocational Education has come to be known as Apprenticeship Training, Vocational Education, Industrial Arts, Technical Education, Technical/ Vocational Education, Occupational Education, Technical Vocational Education and Training and Career and Technical Education (Maclean & Lai, 2011).

Technical Vocational Education and Training is a labour-market relevant programme, which includes work-based components such as apprenticeships (UNESCO, 2011, 11). Technical Vocational Education and Training refers to the "aspects of educational process involving, in addition to general education, the study of technologies and related sciences; as well as the acquisition of practical skills, attitudes, understanding, knowledge relating to occupations in various sectors of economic and social life" (UNESCO, 2011:4). Technical Vocational Education and Training is also understood according to UNESCO (2011:4):

> *as an integral part of general education; a means of preparing for occupational fields and for effective participation in the world of work; an aspect of lifelong learning and a preparation for responsible citizenship; an instrument for promoting environmentally sound sustainable development; and a method of facilitating poverty alleviation.*

Technical Vocational Education and Training systems are built to promote personal, social, civic and economic development in the country (UNESCO, 2015, 6). However, both Technology Education and Vocational Education make a valuable contribution towards the building of a technological workforce. In this regard, Sanders (2003, 182) argues that those who deny the existence of a relationship between Technology Education and Vocational Education are in denial, considering the fact that the fundamental purpose of technological literacy is to contribute to the economy and workforce.

5.7 Names of academic associations

Names of some associations or conferences can also cloud the understanding of Technology Education. An example is the International Society for Technology in Education. This name reads "Technology *in* Education", not "*of* Technology Education"; International Society for Technology Education is an association for *Educational Technology*. However, it is easier to see the difference in the names of other associations and conferences, such as the South African International Conference in Educational Technology, International Science, Mathematics and Technology Education Conference, Southern African Association for Research in Mathematics, Science and Technology Education, and the International Technology and Engineering Educators Association.

6. An adapted meaningful learning in technology education framework

The discussion under sections 4 and 5 suggest a review of the Meaningful Learning in Technology Education Framework as an attempt to contribute to the understanding of Technology Education. The reviewed framework is presented in figure 2. This reviewed Meaningful Learning in Technology Education still acknowledges the influence of Engineering Education on the design. However, it elevates Technology Education and thus adds "process" to "design" to make it more befitting, as it is applied in Technology Education. In figure 2, the centring of the learner in attempts to define and understand Technology Education is maintained, together with the influence of context in addressing problems that are related to authentic contexts.

Explaining Technology Education needs a systems thinking approach, which is not only limited to exploring its meaning through its aspects or relating to Engineering Education only, but also to other subjects, especially those that it is being confused with, in addition to Engineering Education, namely Educational Technology, Science Education and Technical Vocational Education and Training. Technology Education is also better understood by taking into account other external factors such as those discussed in this article. Amongst these are alternative knowledge forms. Specifically, in this article, the focus has been on indigenous knowledge/technology as a form of alternative knowledge. A framework explaining Technology Education that does not intentionally give recognition to indigenous knowledge systems suffers linearity and incompleteness, and can thus, be perceived as perpetuating the colonial agenda. The pragmatic and constructivist paradigms are accommodative of an indigenous paradigm as expressed through what these paradigms purport to achieve in a learning situation – learning as a social enterprise, which encapsulates collaborative problem-solving, team work, group and cooperative learning, active learning and construction of knowledge – the list goes on.

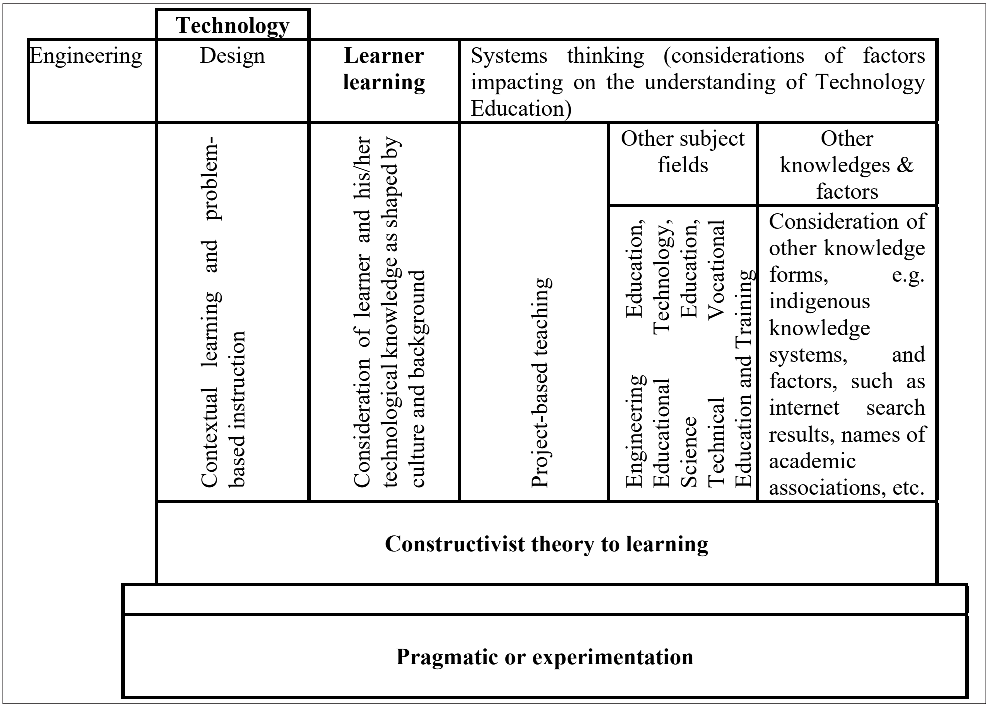

Figure 2: Adapted Meaningful Learning in Technology Education

7. Closing thoughts

This article has addressed the factors that contribute towards the misunderstanding of Technology Education. The article clarified the confusion about Technology Education, which comes through subject fields that lie close to it, namely, Engineering Education, Educational Technology, Science Education and Technical Vocational Education and Training. The fact that these cited subjects are “camouflaged” mistakenly and cryptically as Technology Education created the need to explain their lines of convergence with Technology Education. Most importantly, it was shown that Technology Education is not Engineering Education, Educational Technology, Science Education or even Technical Vocational Education and Training. The main contribution of this study lies in the modified Meaningful Learning in Technology Education that helps to clear the confusion in question and expand the understanding of Technology Education. In addition to the subjects related to or lying closer to Technology Education, this study has identified additional factors. Going forward, Technology Education should not be narrowly explained as that contributes towards its misunderstanding. In addition, it should be explained from frameworks that make room for other knowledge forms and contexts.

References

Al-Ammary, J. 2012. Educational technology: A way to enhance student achievement at the University of Bahrain. *The Online Journal of New Horizons in Education,* 3(3), 54–65.

Almutairi, A.S. 2009. Teachers' perceptions of technology and technology education, years 7 to 10. Unpublished MEd dissertation. Auckland: Auckland University of Technology.

Asunda, P.A. & Hill, R. 2007. Critical features of engineering design in technology education. *Journal of Industrial Teacher Education,* 44(1), 25–48.

Barron, B. & Darling-Harmond, L. 2008. *Teaching for meaningful learning: A review of research on inquiry-based and cooperative learning*. Available at https://www.edutopia.org/pdf/edutopia-teaching-for-meaningful-learning.pdf [Accessed 25 May 2017].

Black, P. 1996. Curricular approaches and models in technology education: Theory, policy and practice. *Proceedings of JISTEC'96*. Jerusalem, Israel, pp. 1–8.

Chikasanda, V.K., Mtemang'ombe, D., Nyirenda, L. & Kapengule, M. 2014. Exploring teaching practice of science and technology in Malawi primary schools. *International Journal of Science and Technology Education Research,* 5(6), 67–78.

Crawford, M.L. 2001. *Teaching contextually: Research, rationale, and techniques for improving student motivation and achievement in mathematics and science*. Waco, TX: CCI Publishing, Inc.

Custer, R.L. 1995: Examining the dimensions of technology. *International Journal of Technology and Design Education,* 5(3), 219–244. https://doi.org/10.1007/BF00769905

Daugherty, M.K. & Wicklein, R.C. 1993. Mathematics, science and technology teachers' perceptions of technology education. *Journal of Technology Education,* 4(2), 28–43. https://doi.org/10.21061/jte.v4i2.a.3

Davies, D. 1997. The relationship between science and technology in the primary curriculum: Alternative perspectives. *The Journal of Design and Technology Education,* 2(2), 101–111.

Department of Basic Education. 2011. *Curriculum and assessment policy statement grades 7–9: Technology*. Pretoria: Government Printers.

Dewey, J. 1930. *Democracy and education*. New York: Free Press.

Dugger, W. 2008. The perspective of technology education. *Proceedings of Japanese International Symposium of Educational Cooperation for Industrial Technology Education*. Chiryu, Japan, pp. 8–20.

Dugger, Jr, W.E. & Naik, N. 2001. Clarifying misconceptions between Technology Education and Educational Technology. *The Technology Teacher,* September, 31–35.

El-Deghaidy, E. & Mansour, N. 2015. Science teachers' perceptions of STEM education: Possibilities and challenges. *International Journal of Learning and Teaching,* 1(1), 51–54. https://doi.org/10.18178/ijlt.1.1.51-54

Gaotlhobogwe, M. 2012. The impact of lack of resources on declining students' enrolments in Design and Technology in Botswana junior secondary schools. *Design and Technology Education: An International Journal,* 17(1), 10–17.

Herschbach, D.R. 2001. *Technology as knowledge: Implications for instruction*. Available at http://scholar.lib.vt.edu/ejournals/JTE/v7n1/pdf/herschbach.pdf [Accessed 3 January 2016].

Indiana Technology Education Curriculum Standards. 2006. T*echnology education content standards booklet*. Indiana: Indiana Department of Education.

International Technology Education Association. 2000. *Standards for technological literacy: Content for the study of technology,* 3rd edition. Virginia: Reston.

Jones, A., Buntting, C. & De Vries, M. 2011. The developing field of technology education: A review to look forward. *International Journal of Technology & Design Education,* 23, 191–212. https://doi.org/10.1007/s10798-011-9174-4

Kelly, T.R. & Kellam, N. (2009). A theoretical framework to guide the re-engineering of technology education. *Journal of Technology Education,* 20(2), 37–49. https://doi.org/10.21061/jte.v20i2.a.3

Kumar, K.L. 2002. *Impact of new technology on teaching and learning in technology education. Paper presented at the Design and Technology Association International Research Conference.* Available at https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/3167/1/Questioning%20the%20design%20and%20technology%20paradigm%20.pdf [Accessed 9 February 2016].

Laufenberg, V, 2009. *About technology*. Available at file://B:\TEKIT\AboutTechnology.mht [Accessed 19 September 2017].

Litowitz, S.L. & Warner, S.A. 2008. Technology education: A contemporary perspective. *Phi Delta Kapan,* 89(7), 519–521. https://doi.org/10.1177/003172170808900714

Maclean, R. & Lai, A. 2011. The future of technical and vocational education and training: Global challenges and possibilities. *International Journal of Training Research,* 9(1–2), 2–15. https://doi.org/10.5172/ijtr.9.1-2.2

Mapotse, T.A. 2012. The teaching practice of senior phase technology education teachers in selected schools of Limpopo province: An action research study. Unpublished PhD thesis. Pretoria: Unisa.

Mapotse, T.A. & Gumbo, M.T. 2013. Identifying grade 8 and 9 technology teachers' areas of need for intervention in Limpopo Province. *Journal of Social Sciences,* 36(1), 19–28.

McCormick, R. 1997. Conceptual and procedural knowledge. *International Journal of Technology and Design Education,* 7, 141–159. https://doi.org/10.1023/A:1008819912213

Moalosi, R. 1999. Historical perspectives of traditional technical subjects in Botswana. *The Journal of Design and Technology Education*, 4(2), 159–160.

Obikeze, D.S. 2011. *Indigenous knowledge systems and the transformation of the academy in Africa: The CULPIP model*. Available at http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.164.9357&rep=rep1&type=pdf [Accessed 10 January 2016].

Ogunbure, A.A. 2011. The possibilities of technological development in Africa: An evaluation of the role of culture. *The Journal of Pan African Studies,* 4(3), 86–100.

Petrina, S. 2003. The educational technology is technology education manifesto. *Journal of Technology Education,* 15(1), 64-74. https://doi.org/10.21061/jte.v15i1.a.5

Pudi, T.I. 2006. Technology education (Study Guide). Pretoria: Unisa Press.

Ruele, V. 2017. Adopting a foreign curriculum in Botswana: Benefits, shortcomings and implications for Africanisation. In M.T. Gumbo & V. Msila (Eds.). *African voices on indigenisation of the curriculum: Insights from practice,* pp. 181-223. Wandsbeck: Reach.

Sanders, M. 2003. The perplexing relationship between technology education and career & technical education in the US. *Proceedings of the American-Australian Technology Education Forum*. Gold Coast, Australia, pp. 182–193.

Senanayake, S.G.J.N. 2006. Indigenous knowledge as a key to sustainable development. *The Journal of Agricultural Sciences,* 2(1), 87–94.

UNESCO. 2011. *Revision of the International Standard Classification of Education (ISCED). Proceedings of the UNESCO General Conference. 36th session*. Available at http://www.emeraldinsight.com/doi/full/10.1108/S0195-6310%282013%290000030017 [Accessed 9 February 2016].

UNESCO. 2015. *World TVET database South Africa*. Bonn: UNESCO.

Volk, K.S. & Dugger, W.E. 2005. East meets west: What Americans and Hong Kong people think about technology. *Journal of Technology Education,* 17(1), 53–68. https://doi.org/10.21061/jte.v17i1.a.4

Williams, A. 1996. What is technology? In J. Williams & A. Williams (Eds.). *Technology education for teachers*. Melbourne: MacMillan.

Williams, P.J. 2011. Engineering: Good for technology education? In M.J. De Vries (Ed.). *Positioning Technology Education in the curriculum*. Rottendam: Sense. https://doi.org/10.1007/978-94-6091-675-5_8